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ANNUAL SCIENTIFIC REPORT

of work completed during the grant year
4-1-80 to 3-31-81
under [redacted]
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Prepared by

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This report is a summary of work completed by the principal investigator, Jay R. Walton, under AFOSR [redacted]-77-3290 for the year 4-1-80 through 3-31-81. Four separate problems were studied. The following sections A), B), C) and D) contain a discussion of the progress made on each problem.

A) In collaboration with Prof. A. Nachman and Prof. J. Tweed of Old Dominion University, the investigation of energy release rate calculations for interface edge cracks was continued. An earlier paper by Nachman and Walton ("Energy release rate calculations for interface edge cracks based on a conservation integral," Int. J. Solids Structures, Vol. 16, 1980, pp. 695-699) addressed a mixed Mode I (opening mode) and Mode II (in plane shearing mode) elastic interface edge fracture. The latest work was for a Mode III (anti-plane shearing mode) deformation as might arise in the torsion of two welded rods. Specifically, the M-conservation integral is applied to the calculation of energy release rates for an edge crack along the interface between two elastic wedges of different opening angles and dissimilar elastic properties, and that is subjected to point loads at the apex. A relation is derived among the length of the crack, the energy release rate of the crack, the applied loads, the wedge angles and the material properties. This work is contained in the paper "Energy Release Rate Calculations for an Interface Mode III Edge Crack Based on a Conservation Integral" which is to appear in the Int. J. Engng. Sci..

As part of a collaborative research effort with Prof. R. A. Schapery of the departments of Aerospace and Civil Engineering, Texas A&M University, the study of the dynamic fracture of linearly viscoelastic material

was continued. The principal investigator considered three separate dynamic crack problems as described in sections B), C) and D) below.

B) An analysis of the anti-plane strain problem of a steadily propagating, semi-infinite crack in an infinite linear viscoelastic body which is subjected to a distribution of shearing tractions moving with the crack was completed. This work is contained in the paper "On the steady state propagation of an anti-plane shear crack in an infinite general linearly viscoelastic body," which is to appear in the Quart. Appl. Math. A description of the results is contained in the abstract from the paper which is attached to this report.

C) An analysis was completed of the dynamic Mode III crack problem for a layer of finite thickness analogous to that described in section B) for an infinite body. A closed form expression for the stress intensity factor was obtained for very general viscoelastic shear modulus. The solution and analysis are very much more complicated for a layer than for an infinite body, but the Riemann-Hilbert method that was employed yields a form for the stress intensity factor that illuminates the combined effects of material inertia and boundary interactions. This work will appear in a paper that is soon to be written and submitted for publication.

D) A study was initiated of the steady-state, dynamic Mode I (opening mode) crack problem for an infinite general linearly viscoelastic body analogous to the Mode III problem described in section B). The Mode I model is more important to engineering applications than the Mode III, but introduces significant additional mathematical complications. The results obtained to date on this problem are preliminary and incomplete and hence will not be described here.

ON THE STEADY STATE PROPAGATION OF AN ANTI-PLANE SHEAR CRACK IN AN INFINITE GENERAL LINEARLY VISCOELASTIC BODY

Abstract

The steady state propagation of a semi-infinite anti-plane shear crack is considered for a general infinite homogeneous and isotropic linearly viscoelastic body. Inertial terms are retained and the only restrictions placed on the shear modulus are that it be positive, continuous, decreasing and convex. For a given integrable distribution of shearing fractions travelling with the crack, a simple closed form solution is obtained for the stress intensity factor and for the entire stress field ahead of and in the plane of the advancing crack. As was observed previously for the standard linear solid, the separate considerations of two distinct cases, defined by parameters c and c^*, arises naturally in the analysis. Specifically, c and c^* denote the elastic shear wave speeds corresponding to zero and infinite time, and the two cases are 1) $0 < v < c^*$ and 2) $c^* < v < c$, where v is the speed of propagation of the crack. For case 1) it is shown that the stress field is the same as in the corresponding elastic problem and is hence independent of v and all material properties. Whereas, for case 2) the stress field depends on both v and material properties. This dependence is shown to be of a very elementary form even for a general viscoelastic shear modulus.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report summarizes progress on certain theoretical questions arising in the study of the fracture mechanics of linearly elastic and viscoelastic material. Specifically, two classes of problems are described:

A. Energy release rate calculations for a Mode III elastic interface edge crack based on the M-conservation integral;

(continued on reverse side)

B. A description of the dynamic stress field ahead of a steadily propagating semi-infinite crack in a general infinite viscoelastic body and in a viscoelastic layer of finite thickness. Both Mode I and Mode III deformations are considered.

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